Δ Open Reduction and Internal Fixation Compared With Primary Subtalar Fusion for Treatment of Sanders Type IV Calcaneal Fractures: A Randomized Multicenter Clinical Trial

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Purpose: There is controversy regarding the surgical treatment of Sanders type IV displaced intra-articular calcaneal fractures (AO-OTA Fracture and Dislocation Compendium, Foot Fracture Classification: 82-C4). The purpose of this study was to determine whether treating Sanders type IV calcaneal fractures with open reduction and internal fixation (ORIF) as compared with primary subtalar fusion (PSF) results in better long-term health outcomes.

Methods: Five surgeons at four Level I trauma centers across Canada participated. Patients were randomized to receive either ORIF or PSF. A standard protocol, involving a lateral approach for ORIF or distraction bone block arthrodesis, was used for the surgical procedures. This protocol arose from surgeons and their experience with a previous large calcaneal operative trial. Health outcomes were assessed with four validated instruments: (1) the Short Form-36 version 2 (SF-36), (2) the Musculoskeletal Function Assessment Survey (MFA), (3) the American Orthopaedic Foot & Ankle Society's Ankle-Hindfoot Scale (AHS), and (4) the visual analog scale (VAS). Follow-up was for a minimum of 2-7 years.

Results: From 2004 to 2011, 31 patients with 31 fractures were included in the study. 17 patients received ORIF; 14 received PSF. The two groups had no difference in demographics (severity of fracture, age, gender, smoking, and Workers' Compensation Board status). 26 patients were followed and assessed for a minimum of 2 years and a maximum of 7 years (84% follow-up). Five patients were lost to follow-up. For each health outcome, we report the mean score with standard deviation (SD) for both surgical treatments and the *P* value. No statistically significant difference was found between the results for ORIF compared with PSF: the mean SF-36 physical component scores were 30.2 (SD 11.4) and 37.8 (SD 10.4), respectively ($P = 0.10$); the mean MFA scores were 44.2 (SD 25.6) and 37.9 (SD 21.5), respectively ($P = 0.50$); the mean AHS scores were 62.5 (SD 19.6) and 65.8 (SD 19.2), respectively ($P = 0.68$); and the mean VAS scores were 36.8 (SD 34.7) and 33.9 (SD 30.7), respectively ($P = 0.82$).

Conclusion: We did not find a difference between treating Sanders type IV fractures with ORIF compared with PSF. Either of the two treatment modalities may be optimal for this fracture. It remains the choice of the surgeon and patient to take into account patient specific factors to determine treatment.

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Combined Approaches Increase Nonunion in Tibial Pilon Fractures

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Background/Purpose: Staged fixation of tibial pilon fractures has become commonplace. There is very little literature, however, discussing the staged fixation of the tibia through separate incisions. Recent evidence has suggested that a staged approach to the posterior tibia may offer improved articular reductions at the time of anterior fixation. To date, no large series of patients with staged posterior fixation has been compared with isolated anterior fixation to determine if this improvement in reduction holds true.

Methods: From January 1, 2005 to December 31, 2011, all records of patients treated for 43C fractures of the distal tibia were reviewed. Patients in this retrospective clinical cohort were grouped according to posterior-anterior and anterior-alone approaches. Medical charts and surgical documentation were reviewed and postoperative CT scans were examined for residual articular displacement and quantified. Ultimate union rate was correlated with approach strategy. Articular reduction was subdivided into three groups (<1 mm, 1-2 mm, >2 mm).

Results: 116 patients were identified as having had 43C fractures treated surgically with postoperative CT scans completed. 26 fractures presented as an open injury. Of these 116 patients, 35 underwent staged fixation of the posterior malleolus at an average of 10 days postinjury, followed by delayed anterior fixation at an average of 16 days postinjury. The remaining 81 patients underwent anterior fixation alone. 21 patients were lost to follow-up prior to 6 months. Of the 95 patients with sufficient follow-up, there were 24 nonunions. There was a statistically significant association of nonunion with staged posterior approach (40% vs 19%, $P = 0.015$). CT reduction for staged-posterior versus anterior-alone approach was not significantly different for any of the three categories (63% vs 57% <1 mm, 31% vs 26% 1-2 mm, 6% vs 17% >2 mm).

Conclusion: There is no statistically proven benefit to combined surgical approaches to tibial pilon fractures. It appears from this investigation that there is a significantly higher risk of nonunion with no demonstrable benefit to articular reduction. While articular reduction is of paramount importance, aggressive approaches to direct reduction and fixation of all fragments may lead to further complications.

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Long-Term Follow-up of High-Energy Pilon Fractures:
A Prospective Comparison of Locked Plates Versus Nonlocked Plates

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Purpose: This study was undertaken to compare the clinical and radiographic outcomes of patients treated with either locking plates or conventional nonlocking plates in the management of high-energy pilon fractures. Our null hypothesis is that there would be no significant difference in the incidence of loss of reduction or functional outcomes between nonlocked and locked plates in the treatment of high-energy pilon fractures.

Methods: A prospective treatment protocol on patients with high-energy pilon fractures treated at a Level I trauma center between December 2005 and December 2008 was established and followed. Patients were randomized to either locking or nonlocking devices according to their medical record number. Radiographic outcomes were assessed with at least 6-month follow-up. Mortise/AP and lateral radiographs of the ankle were evaluated at the latest follow-up to assess for loss of reduction compared to radiographs at the time of surgery. This was defined as an angle measurement change ≥5°. Ankle hindfoot scores and Short Musculoskeletal Function Assessment (SMFA) functional outcome scores were collected on all patients with at least 1-year follow-up.

Results: From December 2005 through December 2008, 58 patients were randomized to receiving either a locked or a nonlocked plate for the treatment of high-energy pilon fractures. Radiographic measurements at a minimum of 6 months were available for 34 fractures (33 patients). There were 19 fractures in Group Nonlock and 15 in Group Lock. The average follow up was 30.6 ± 15.7 months (range, 8-67). Fracture classification included 25 OTA 43-C3, five 43-C2, two 43-C1, and two 43-B3 fractures. Mechanisms of injury included 11 falls from a height greater than 10 feet, 12 falls from standing, 7 motor vehicle accidents, and 3 other injuries. On the mortise view, 2 of 15 (13%) fractures in Group Nonlock demonstrated loss of reduction >5° compared to 3 of 19 (16%) in Group Lock ($P = 0.999$). There were no soft-tissue complications that required surgical intervention. In terms of complications, Group Lock had 1 patient with a deep infection, 2 nonunions, and 2 hardware failures. Group Nonlock had 1 hardware failure and 1 infected nonunion. Functional outcome scores were available for 18 patients (31%), 8 patients in Group Lock and 10 in Group Nonlock, with an average follow-up of 35.6 ± 16.0 months (range, 13-67). There was no significant difference between the ankle hindfoot scores (Lock: 71.75 ± 71.75; Nonlock: 66.1 ± 23.8; $P = 0.625$), the SMFA-BI (bother index) scores (Lock: 7175 ± 25.4; Nonlock: 66.1±23.8; $P = 0.625$), or the SMFA-FI (function index) scores (Lock: 32.9 ±36.2; Nonlock: 25.7 ± 20.2; $P = 0.587$).

Conclusion: The staged protocol for the treatment of high-energy pilon fractures has overcome the soft-tissue complications previously encountered. However, our data demonstrated that locking constructs have not improved the overall outcome of high-energy pilon fractures in terms of maintaining reduction or functional outcomes. However, given the low incidence of reduction lost in this study, the possibility of a type II error must be considered.

See pages 91 - 132 for financial disclosure information.

Δ Early Weight Bearing and Mobilization Versus Non–Weight Bearing and Immobilization After Open Reduction and Internal Fixation of Unstable Ankle Fractures: A Randomized Controlled Trial

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Background/Purpose: The optimal postoperative protocol with respect to weight bearing and ankle range of motion (ROM) following surgical fixation of acute ankle fractures remains elusive. Convention dictates non–weight bearing and immobilization for 6 weeks postoperatively, but early weight bearing may expedite return to function (with the potential risk of loss of fixation or wound complications). Our goal was to conduct a randomized controlled trial comparing early weight bearing and mobilization versus non–weight bearing and immobilization after surgical fixation of unstable ankle fractures.

Methods: We conducted a multicenter randomized controlled trial at two Level I trauma centers. Patients who underwent acute surgical fixation of an unstable ankle fracture were recruited and randomized to one of two rehabilitation protocols: (1) early weight bearing (weight bearing and ankle mobilization at 2 weeks) or (2) delayed weight bearing (non–weight bearing and casting for 6 weeks). Patients with posterior malleolar fixation or syndesmosis injuries were excluded. Patients were seen in follow-up at 2 weeks, 6 weeks, 3 months, 6 months, and 12 months postoperatively. The primary outcome was rate of return to work; secondary outcomes included ankle ROM, SF-36 (Short Form-36) heath outcome scores, Olerud/Molander ankle function score, and rates of complications (wound complication, loss of reduction, hardware failure, reoperation).

Results: In total 110 patients were recruited: 56 were randomized to early weight bearing and 54 were randomized to the delayed weight-bearing group. Patients were 47% female, 53% male, with a mean age of 42 years; there were no differences between the two groups with regard to demographics, preinjury type of occupation, type of fracture, or time to surgery. There was no difference between the two groups with regards to rate of return to work at any time point. However, at 6 weeks postoperatively, patients in the early weight-bearing group had significantly improved ankle ROM (42° vs 28°, $P = 0.001$), significantly improved Olerud/Molander ankle function scores (44 vs 31, $P = 0.002$), as well as significantly improved SF-36 scores on both the physical (50 vs 42, $P = 0.008$) and mental (62 vs 54, $P = 0.005$) components. There were no cases of fixation failure, loss of reduction, or repeat operation in either group. There were also no differences with regards to wound complications or infections.

Conclusion: This randomized study of early versus delayed weight bearing demonstrated no significant difference with regard to rate of return to work in patients with surgically treated ankle fractures. However, patients treated with the early weight-bearing protocol had significantly improved ankle function, ankle ROM, and improved mental and physical

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health outcome scores early in the postoperative period. There were no failures of fixation or differences in wound complications between the two groups. Given the convenience for the patient, the early improved functional outcome, and the lack of an increased complication rate with early weight bearing, we recommend early postoperative mobilization and weight bearing in patients with surgically treated ankle fractures.

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Does the Müller AO Classification System for Ankle Fractures Correlate More Closely to the Mechanism of Injury Than the Lauge-Hansen System?

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Purpose: This study was conducted to assess whether the Lauge-Hansen (LH) and the Müller AO classification systems for ankle fractures radiographically correlate consistently with real in vivo injuries as based on observed mechanism of injury.

Methods: Videos of potential study candidates sustaining ankle injuries were reviewed on YouTube.com and individuals were recruited for participation if the video was of sufficient quality to classify the injury mechanism and if the individual demonstrated sufficient trauma likely to have sustained an ankle fracture. Corresponding injury radiographs were obtained. Injury mechanism seen in the video clips was classified using the LH system as supination/external rotation (SER), supination/adduction (SAD), pronation/external rotation (PER), or pronation/abduction (PAB). Corresponding radiographs were classified by the LH system and the AO system.

Results: Of over 2500 video clips reviewed, 625 demonstrated an injury mechanism classifiable by the LH system with a likelihood of sustaining an ankle fracture and were invited to participate. Of the 116 responders, 30 injury videos with their corresponding radiographs were collected. Of the video clips reviewed, 16 had SAD deforming trauma and 14 had PER deforming trauma. There were 26 ankle fractures, 3 nonfractures and 1 subtalar dislocation. 12 fractures judged by video to be SAD injuries had corresponding SAD fracture patterns. Five PER video injuries had PER fracture patterns. Eight PER video injuries resulted in SER fracture patterns and one resulted in a SAD fracture pattern. When using the AO classification, all 12 SAD type injuries that resulted in a fracture resulted in 44A type fractures while the 14 PER injuries resulted in nine 44B fractures, two 44C fractures, and three 43A fractures.

Conclusion: When in vivo video injury clips of ankle fractures are matched to their corresponding radiographs, the LH system is 65% consistent in predicting fracture patterns from deforming injury mechanism. When using the AO classification system, overall consistency was 81%, as a PER mechanism appears to mostly result in 44B type fractures. The AO classification, despite its development as a purely radiographic system, appears to correlate with in vivo injuries more consistently than the LH system.

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The Quality and Utility of Routine Immediate Postoperative Radiographs Following Ankle Fracture Surgery

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Background/Purpose: Patients who undergo open reduction and internal fixation of ankle fractures commonly undergo routine postoperative ankle imaging. As these patients are typically immobilized in splints or casts, postoperative ankle radiographs often provide limited visualization due to casting material and patient positioning. These radiographs confer additional radiation exposure to the patient and are a direct cost to the hospital and patient. The purpose of this study is to evaluate the utility and quality of routine immediate postoperative radiographs following ankle fracture surgery.

Methods: All ankle fractures undergoing open reduction and internal fixation at a single institution from January 1, 2011 to January 1, 2012 were reviewed. Immediate postoperative radiographs were evaluated using defined parameters to determine if three quality views (AP, lateral, and mortise) were obtained. The quality of the postoperative images was compared to that of saved intraoperative fluoroscopic images. Postoperative complications were evaluated in terms of fracture displacement, hardware malpositioning, and need for return to the operating room. A cost analysis was performed to determine the overall cost of postoperative radiographs.

Results: A total of 203 patients with 205 ankle fractures underwent surgical fixation, with 136 patients undergoing routine postoperative radiographs. Only 18 patients (13.2%) had three quality postoperative views of the ankle with the mortise (52.8%) and lateral (65.9%) views commonly performed with poor technique. No postoperative series offered improved visualization of the fracture compared with saved intraoperative fluoroscopic images. None of the patients without radiographs had a complication that could have been detected earlier using postoperative radiographs. Only one patient (0.49%) had displacement identified on postoperative films not seen on intraoperative images. This patient experienced increasing pain following marginal fixation and did not require return to the operating room. No fracture malalignment or hardware malposition was seen that was not visualized retrospectively on fluoroscopic images. No patients required return to the operating room based on immediate postoperative films. Postoperative radiographs increased the total cost by $191.00 per patient.

Conclusion: The routine use of immediate postoperative radiographs following ankle fracture surgery does not provide additional value to the patient or orthopaedic surgeon. The quality of these images is generally inferior to those obtained and saved intraoperatively due to malrotation and overlying cast material. To reduce cost and radiation exposure, immediate postoperative radiographs should only be obtained following intraoperative fluoroscopy in specific circumstances, such as increasing postoperative pain, marginal fixation, or instability.

See pages 91 - 132 for financial disclosure information.

A Prospective Randomized Multicentric Trial Comparing a Static Implant to a Dynamic Implant in the Surgical Treatment of Acute Ankle Syndesmosis Rupture

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Purpose: Syndesmosis rupture is involved in 13% of ankle fractures and requires surgical stablilization. The recent trend toward dynamic fixation with an Endobutton is not yet supported by clinical randomized trials. The purpose of this study is to compare the functional outcome after stabilization of an acute syndesmosis rupture with either a static implant (a 3.5-mm metallic screw through four cortices) or a dynamic device (TightRope, Arthrex).

Methods: We conducted a randomized double-blind controlled trial involving 70 subjects (in five centers) with an acute syndesmosis rupture, stabilized either with a TightRope (n = 34) or a quadricortical screw (n = 36). The two groups were similar regarding demographic, social and surgical data. Main outcome was Olerud-Molander score at 6 months. A 1-year follow-up included (at 3, 6, and 12 months) functional status (Olerud-Molander, AOFAS [American Orthopaedic Foot & Ankle Society] ankle-hindfoot score, time to activities, ankle range of motion) and radiological evaluation (loss of reduction, implant failure). Reoperations and complications were recorded.

Results: Subjects with dynamic fixation achieved significantly higher performances as described with the Olerud-Molander scores at 3 (68.8 vs 60.2, $P < 0.05$), 6 (84.2 vs 76.8, $P < 0.05$), and 12 months (93.3 vs 87.6, $P < 0.05$). We also observed better AOFAS scores at 3 (78.6 vs 70.6, $P < 0.05$), 6 (87.1 vs 83.8, $P = 0.13$), and 12 months (93.1 vs 89.9, $P = 0.13$). Plantar flexion was superior with dynamic fixation at all times. Implant failure was higher in the screw group (36.1% vs 0%, $P < 0.05$). Loss of reduction was observed in 4 cases in the static screw group (11.1% vs 0%, $P = 0.06$). Reoperation for any cause was more frequent in the screw group (33.3% vs 5.9%, $P < 0.05$). We could not demonstrate major differences in the activity level between the two groups, except that subjects with dynamic fixation returned earlier to their previous sporting activities.

Conclusion: Dynamic fixation of acute ankle syndesmosis rupture with the TightRope gives better functional outcomes at short and intermediate terms. The implant offers adequate syndesmosis stabilization without breakage or loss of reduction and reoperation rate is significantly lower than with the conventional screw fixation.

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The Fate of the Fixed Syndesmosis Over Time

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Background/Purpose: A prior study demonstrated statistical widening of the syndesmosis within weeks of elective screw removal. However, no information is available as to the radiographic outcomes of screw retention. The purpose of this study is to evaluate syndesmotic widening and talar shift over time in patients treated with syndesmotic screws and to compare removal versus retention along with other potential risk factors that may lead to syndesmotic widening over time.

Methods: A consecutive series of patients with ankle fractures and associated syndesmotic disruption treated with open reduction and internal fixation (ORIF) were reviewed. Demographic data, fracture classification, fixation, syndesmotic screw outcomes (removal, loosening/breakage, or retained and solid), and radiographic findings (MCS = medial clear space, CS = tibia-fibula space, and OL =tibia-fibula overlap) on the mortise and AP radiographs were evaluated at presentation, immediately postoperative, and final follow-up at a median of 6 months. Screw removal was offered to patients and performed at 12 weeks if chosen. *T* tests were used to compare postoperative and final follow-up measurements as well as groups of interest.

Results: 166 patients (94 men and 72 women) aged 16 to 83 years (average = 39.9) treated operatively for syndesmotic disruption comprise the study population. There were 84 SE (supination external rotation), 54 PE (pronation external rotation), and 28 PA (pronation abduction) injuries. 39 (23%) presented with dislocation. 123 were treated with a plate and syndesmotic screws and 43 with syndesmosis-only fixation. Postoperative radiographic alignment was not affected by fracture type, presence of initial dislocation, or use of a plate. 58 (35%) of the patients had their screws removed by choice, and at final follow-up 17 (16%) of the remaining patients' screws were solid and 91 (84%) were loose or broken. The following table details the measurements for all patients:

All Patients	Tibia-Fibula CS			Tibia-Fibula OL			Tibiotalar MCS		
	Preop	Postop	Final	Preop	Postop	Final	Preop	Postop	Final
AP	6.24	3.66	4.05*	4.78	6.89	7.35	4.24	2.31	2.05
Mortise	7.46	3.76	4.24*	–0.41	3.29	3.02	4.73	2.19	2.21

*Significance with $P < 0.05$.

There was an approximately 0.5-mm shift in the fibula over time compared to the postoperative radiograph (AP, $P = 0.02$; mortise, $P = 0.003$) without any change in MCS, indicating that the mortise remained intact without talar shift. We compared those whose screws were removed versus retained, screws removed grouped with those that were loose/broken versus solid and retained, those who presented dislocated versus not, fixed with a plate versus screws only, and Weber B versus C injuries on the AP and mortise views for all measure-

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ments. The only significant finding was a slightly greater CS (4.6 mm vs 4.1 mm, $P = 0.02$) and lower OL (2.4 mm vs 3.3 mm, $P = 0.03$) on the mortise view for those whose screws were removed by choice as compared with those whose screws were retained, regardless of loosening or breakage. These differences were only 0.5 mm and 1.1 mm, and did not reach statistical significance after adjusting for multiple evaluations (reset of $P < 0.005$ Bonferroni correction).

Conclusion: In contradistinction to prior work, we found only very mild widening (0.5 mm) of the tibia-fibula space occurs over time after syndesmotic fixation. Removal of syndesmotic screws at 3 months results in slightly less OL (~1 mm) and greater CS (0.5 mm) than screw retention even if the retained screws loosened or broke, but this was not associated with any talar subluxation. These differences were not statistically significant, and were quite small (<1 mm). The mortise in patients remains intact regardless of whether the syndesmotic screws are removed, loosen or break, or remain solid and in place.

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Does Syndesmotic Injury Have a Negative Effect on Functional Outcomes? A Multicenter Prospective Evaluation

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Background/Purpose: A negative prognosis has been reported for indirect ankle fractures with associated syndesmotic disruption as compared to those without syndesmotic injury. However, no report has separated Weber C from B injuries as a confounding variable. Ideally, this factor should be eliminated from the analysis to truly understand the effect of syndesmotic injury. Our purpose was to evaluate the effect of syndesmotic disruption on the functional outcomes of Weber B, SE4 (supination external rotation) ankle fractures treated surgically.

Methods: We performed a prospective multicenter evaluation of 242 patients (136 women, 106 men) with Weber B SE4 ankle fractures treated surgically. The average age was 46 years (range, 18-83). 81 (35%) of these patients had intraoperatively confirmed syndesmotic instability after fibular fixation and were reduced and fixed with syndesmotic screws. Outcomes evaluated at 6 weeks and 3, 6, 9, and 12 months included Short Musculoskeletal Function Assessment (SMFA), Bother Index, and American Orthopaedic Foot & Ankle Society (AOFAS) scores as well as symptomatic hardware and peroneal tendon discomfort. Statistical analysis was done using a mixed linear regression analysis using adjusted means with Tukey's method to account for repeated measures by a PhD statistician for functional outcomes to evaluate the recovery curve of the two groups, and for gender and race. *T* tests and χ^2 were used for other variables at the final 1-year outcomes.

Results: The adjusted means regression analyses demonstrated that patients without a syndesmotic injury had better SMFA scores at 12 weeks ($P = 0.02$), but not at 6, 26, or 52 weeks ($P = 0.76, 0.73, 0.32$). No syndesmotic injury also resulted in statistically better scores for the AOFAS ($P = 0.0006$) and trended toward better results for the Bother Index ($P = 0.07$). Men had better results than women for all outcomes: SMFA ($P = 0.002$), Bother Index ($P = 0.008$), and AOFAS ($P = 0.0006$). Race was not a significant factor for any score. Isolated analysis of the 1-year results revealed a difference in the SMFA and Bother Index, but not the AOFAS (Table). At 9 to 12 months, hardware was symptomatic in 17% of patients with and 10% of those without syndesmotic fixation ($P = 0.28$), and peroneal symptoms present in 14% and 8%, respectively ($P = 0.24$).

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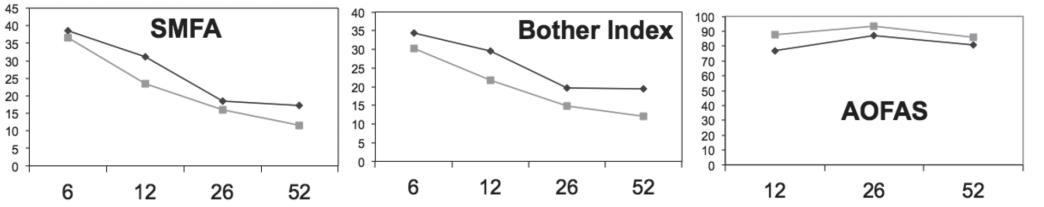
Table 1: One-Year Results

Group	SMFA	Bother	AOFAS
Syndesmosis injury	17.19	19.36	80.58
No syndesmotic injury	11.60	12.06	85.89
P value	0.04	0.05	0.21



Conclusion: Syndesmotic instability in association with Weber B, SE4 ankle fractures had worse outcomes at 1 year using the SMFA and bother indices. The difference was at the limit of clinical significance (1/2 standard deviation). Additionally, mixed linear regression over time demonstrated better results for the SMFA (only at 6 weeks) and the AOFAS with the Bother Index just outside of statistical significance. The most consistent finding, however, was better outcomes for men for all measures at all time points. Syndesmotic injury has a slightly detrimental effect on outcomes of surgically treated Weber B SE4 fractures.

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Stress Ankle Radiographs and Predictability of Deep Deltoid Ligament Injury in a Supination–External Rotation Cohort

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Background/Purpose: Stress ankle radiographs are commonly performed to determine deltoid ligament integrity in patients with a supination–external rotation (SER) pattern ankle fracture. Recognition of a medial-sided injury in this cohort is important as this fracture pattern is considered unstable and it has been shown that these patients benefit from surgical stabilization. However, there is variability in the literature as to what constitutes a positive stress ankle radiograph and to date only cadaver studies have examined the sensitivity and specificity of differing medial clear space (MCS) measurements. The purpose of our study was to compare the injury and stress radiographs of SER-pattern ankle fractures with or without a deep deltoid ligament injury and determine the predictive ability of the MCS in identifying a deltoid ligament tear.

Methods: All patients with an SER-pattern fibula fracture without a medial malleolus fracture from 2006 to 2012 were identified from the senior surgeon's prospectively collected ankle fracture database. Only patients with injury ankle radiographs, an external rotation stress radiograph, and an ankle MRI scan within 1 week of the injury were included for analysis. All stress radiographs were performed in the emergency department by an on-call orthopaedic resident. MCS was measured using our institution's picture archiving and communication system (PACS) and represented the distance from the medial aspect of the talus horizontally to the articular surface of the medial malleolus at the talar dome. This distance was measured and recorded for both the non-stress and stress ankle mortise radiographs. The integrity of the deep deltoid ligament was by two independent and blinded fellowship-trained attending musculoskeletal radiologists based on the ankle MRI.

Results: 52 patients were eligible for analysis. The average patient age was 47.5 years and 53.8% (28 of 52) were male. Of the 52 patients, 50% (26) had no MRI evidence of a deep deltoid ligament rupture and therefore were classified as an SER II or SER III injury. The other 50% (26 of 52) were classified as SER IV equivalent injuries due to MRI evidence of a high-grade deep deltoid ligament tear. SER II/III patients demonstrated an average MCS distance of 4.34 mm during stress radiographs. The SER IV cohort's average MCS was 5.81 mm when the ankle was stressed. Comparison of the average MCS measurements between the two groups was significantly different (P <0.001). Finally, an absolute MCS on stress radiograph of greater than 5.0 mm had a calculated 65.4% sensitivity and 76.9% specificity for identifying a deep deltoid ligament tear. The corresponding positive and negative predictive values were 73.9% and 69.0%, respectively.

Conclusion: External rotation stress ankle radiographs are a common method for determining deltoid ligament integrity in patients with an SER ankle fracture. We have shown that stress radiographs are able to accurately distinguish between patients with or without a deep deltoid ligament injury based on the extent of MCS widening. We also found that a stress view MCS measurement greater than 5.0 mm had a 65.4% sensitivity and 76.9% specificity for identifying a deep deltoid ligament tear.

See pages 91 - 132 for financial disclosure information.

Anatomical Fixation of Supination–External Rotation Type IV Equivalent Ankle Fractures

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Background/Purpose: Ankle fracture fixation continues to challenge orthopaedists despite the plethora of research into novel fixation strategies. Outcomes vary with these novel strategies, but discrepancies continue to exist regarding the most successful means of fixation. We have previously published our fracture-specific treatment strategy for supination–external rotation (SER) ankle fractures, which has exhibited equivalent outcomes between boney and ligamentous injuries as well as between geriatric and nongeriatric populations. These results have been contrary to previously published literature and previously held dogma. The goal of this study is to extend that anatomical treatment strategy to supination type IV equivalent (SER IV E) ligamentous injuries and compare our previous patients with our current strategy of deltoid and posterior inferior tibiofibular ligament (PITFL) repair. We hypothesize that our radiographic and functional outcomes will be improved with the addition of ligamentous repair.

Methods: This is an IRB-approved evaluation of a prospectively collected database of a single surgeon from a Level I trauma center. All MRI-confirmed SER IV E (45 patients) ankle fractures treated between 2004 and 2011 with at least 1-year clinical follow-up were included in this cohort. Prior to 2010 all SER IV E ankle fractures were treated with lateral malleolus fixation and transsyndesmotic screws in the setting of a positive intraoperative stress test. Since 2010 all SER IV E ankle fractures have undergone PITFL fixation with a soft-tissue washer and 3.5-mm cortical screw followed by an intraoperative stress test. Deltoid ligament repair with a medial malleolus or talus suture anchor was reserved for intraoperative stress showing increased talar tilt or increased medial clear space (MCS). All patients underwent immediate postoperative bilateral CT scans to evaluate articular reduction and syndesmotic reduction. Postoperative radiographs measuring tibiofibular clear space (TCS) and MCS were performed. Change in TCS or MCS >2 mm from initial radiographs was considered a loss of reduction. Greater than 2 mm difference in anterior or posterior syndesmotic width when compared to the uninjured side was considered a syndesmotic malreduction. Functional outcome scores as measured by the Foot and Ankle Outcome Score (FAOS) were compared for patients with at least 1-year functional outcome score follow-up.

Results: There was no significant difference in mean postoperative TCS, MCS, or change in TCS or MCS between the cohorts. The anatomical treatment group had significantly better postoperative syndesmotic reduction compared to the nonanatomical cohort (7.4% vs 21.4%; $P = 0.02$). The mean difference in syndesmotic width for the nonanatomical cohort was 1.8 mm compared to 0.9 mm in the anatomical cohort. All transsyndemostic screws were removed at 4 months in the nonanatomical cohort (14 patients). The nonanatomical cohort had slightly better dorsiflexion of ankle (mean 19° vs 17°; $P = 0.02$). The nonanatomical group had significantly better functional outcome scores in all categories of the FAOS outcomes

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score (quality of life, return to sports, activities of daily living, pain, and symptoms) despite worse syndesmotic reduction.

Conclusion: This comparison of treatment strategies for SER IV E ankle fractures has shown an improvement in immediate postoperative syndesmotic reduction and the elimination of reoperation for removal of transsyndesmotic screws, but this does not translate to improved functional outcomes in this cohort. While short-term outcomes (1 year) appear worse, longer-term investigation of these patients is necessary to determine the impact of the anatomical treatment strategy on posttraumatic osteoarthritis and poorer future outcomes.

See pages 91 - 132 for financial disclosure information.